Montana Bureau of Mines and Geology
A Department of Montana Tech of The University of Montana

Montana Ground-Water Assessment Atlas 4, Part B, Map 3
July 2006

Thickness of Quaternary Unconsolidated Deposits in the Lolo-Bitterroot Area, Mineral, Missoula, and Ravalli Counties, Montana

by

Larry N. Smith

Author's Note: This map is part of the Montana Bureau of Mines and Geology (MBMG) Ground-Water Assessment Atlas for the Lolo-Bitterroot Area ground-water characterization. It is intended to stand alone and describe a single hydrogeologic aspect of the study area, although many of the area's hydrogeologic features are interrelated. For an integrated view of the hydrogeology of the Lolo-Bitterroot Area the reader is referred to Part A (descriptive overview) and Part B (maps) of the Montana Ground-Water Assessment Atlas 4.

INTRODUCTION

This map shows the thickness of unconsolidated Quaternary sand and gravel, including lesser amounts of silt and clay, that is present near the land surface in Mineral, Ravalli, and Missoula counties (outside the Flathead Indian Reservation). Unconsolidated deposits near land surface are important hydrogeologic units because where they are coarse grained, highly permeable, and saturated with ground water, they are aquifers. The narrow canyon reaches downstream from Alberton and upstream of Darby are excluded from the map because of the narrowness of the canyon and sparse data.

Coarse-grained unconsolidated deposits occur throughout the Lolo-Bitterroot Area along modern streams where ground water is typically close to the surface. Coarse-grained, near-stream deposits are where surface water–ground water interactions occur. Relatively coarse-grained, permeable gravels and sands include those deposited along stream floodplains, alluvial fans, and in areas of glacial outwash (sand and gravel deposits of streams in front of former glaciers).

Relatively fine-grained, impermeable deposits include silts and sands deposited from standing water, on river floodplains and in Glacial Lake Missoula, and local areas of silty gravel deposited by glacial ice. Some fine-grained unconsolidated deposits occur on local surfaces, mostly on terraces within the major valleys and in some foothill areas. The unconsolidated deposits occur mostly along the Clark Fork River and its tributaries; smaller thicknesses were deposited along the Bitterroot River and its tributaries. The surficial distributions of the fine- and coarse-grained deposits are shown in Smith (2006b).

The Quaternary deposits and underlying Tertiary sedimentary rocks are considered basin-fill deposits in this report. Bedrock in foothill areas and in valley centers is consolidated to the extent that it is permeable only along fractures; these units include granitic, volcanic, and Belt Supergroup rocks (Smith, 2006b). Interpretation of drillers' logs of water wells and examination of surface exposures in the field show that the unconsolidated deposits are widespread, but can be correlated with confidence in the subsurface only where thicknesses reported on the logs are greater than 10 ft.

DATA SOURCES AND MAP CONSTRUCTION

Data used for contouring the thickness of unconsolidated deposits come from descriptive lithologic logs of water wells. Of the nearly 27,000 water wells in the Lolo-Bitterroot Area, a subset was selected of about 2,500 drillers' logs of wells that completely penetrated the unconsolidated deposits. About 1,800 of the wells showed thicknesses of unconsolidated deposits greater than 10 ft. An additional 1,600 well logs that did not completely penetrate the unconsolidated deposits provided estimates of minimum thickness. Well logs were chosen based on areal distribution, well depth, lithologic detail, and locational accuracy. Most well locations used are those reported by drillers; of the ~2,500 wells, 952 were located during field inventory work.

Because irregularities in the land surface make contouring the thickness of the upper geologic unit difficult, a two-step contouring process was used. Land-surface altitudes at well locations were obtained either from the 1:24,000-scale U.S. Geological Survey Digital Elevation Models (DEMs) using ArcInfo™ computer software or from 1:24,000-scale topographic maps for wells located in the field. Land-surface altitudes and well logs were used to contour-map altitudes of the basal contact of the unconsolidated deposits. Then the altitude map was converted to a thickness map by subtraction of the topographic surface derived from the DEM. The final thickness contours were reinterpreted by hand.

Water-well driller logs and well locations are stored in the GWIC database at the Montana Bureau of Mines and Geology (http://mbmggwic.mtech.edu). Ground-surface topographic data are from the 1:24,000-scale U.S. Geological Survey DEMs for western Montana. Public Land System Survey data, hydrography, and roads were obtained from Montana's Natural Resources Information System, Helena (http://nris.state.mt.us/).

DISCUSSION

The major valleys in the area, the Missoula, Bitterroot, Ninemile, Potomac, and Seeley Lake valleys, contain a succession of partially consolidated Tertiary sedimentary rocks between indurated bedrock in neighboring uplifted mountain ranges. Surficial unconsolidated deposits overlie the weakly to moderately consolidated Tertiary rocks and older bedrock in the major valleys. Along the Clark Fork River canyons and tributaries, unconsolidated deposits were mostly deposited on bedrock. Thickness variations shown on the map were caused by erosion of underlying units before deposition and by irregularities in the present land surface.

Although no age control is available for most of the deposits, limited data suggest they have been formed in the last 2 million years, or during the Quaternary geologic period. Glaciers extended into the Missoula and Bitterroot valleys only in small areas, depositing local areas of till near valley margins. Mountains and valleys in the northeastern portion of the map area were mostly glaciated, including the Seeley and Placid Lake basins and all of the valleys north of the Blackfoot River. Importantly, most of the Missoula, Bitterroot, and Ninemile valleys and the Clark Fork River canyons were covered by Glacial Lake Missoula multiple times during the last glaciation about 15–20,000 years ago. The laminated silt and clay deposited in Glacial Lake Missoula provide the only stratigraphic control on the ages of the unconsolidated deposits. Thick gravelly deposits beneath the silty lake deposits, mostly along the Clark Fork River, show large-scale cross-stratification that is evidence for high-energy drainage of one or more glacial-lake stands (Smith, in press). These deposits are overlain by the laminated silt and clay deposits that are commonly observed around the Missoula Valley and canyons of the Clark Fork River.

Missoula Valley

The Missoula Valley, from Hellgate Canyon to northwest of Frenchtown, is covered with unconsolidated sediment except for where three bedrock knobs are exposed. The bedrock surface beneath the valley is irregular (Smith, 2006a), as is the erosional surface on top of the Tertiary sedimentary rocks. Beneath the city of Missoula, Quaternary alluvium extends to depths that have not been fully penetrated by wells, so the total thicknesses are not known. Extrapolation from the few wells in the area suggests that thicknesses may exceed 300 ft. Deposits thicken eastward from near the confluence of the Clark Fork and Bitterroot rivers toward Hellgate Canyon, partially due to the rising topographic surface. Wells in the Frenchtown area are drilled to the base of the unconsolidated deposits and show thicknesses exceeding 200 ft. Water well log data from south of Frenchtown to west of Huson define a paleochannel along the northern side of the valley.

Bitterroot Valley

Based on interpretation of logs from about 550 of the 8,700 wells drilled into Quaternary deposits in the Bitterroot Valley, unconsolidated deposits are generally about 50 ft thick. In the northern and narrower part of the valley, between Miller and Eightmile creeks, the deposits are greater than 100 ft and possibly as much as 150 ft thick. In the central part of the valley, between Florence and Hamilton, differentiating the sand and gravel in the surficial units from the underlying sand and gravel in Tertiary sedimentary rocks using descriptive drillers' logs is difficult. On the west side of the valley between Florence and Hamilton, weakly consolidated Tertiary conglomerate underlies the unconsolidated Quaternary deposits. The two units can be distinguished where more consolidated clayey interbeds in the Tertiary conglomerate are encountered, but if the clayey interbeds are not present, they form a single, shallow gravelly unit that is indistinguishable on drillers' logs.

In the southern part of the valley, near Hamilton, the Quaternary deposits thicken to 100–150 ft in local areas where till and other glacial deposits accumulated near the mouths of canyons, such as at Blodgett, Roaring Lion, Lost Horse, Rock, and Tin Cup creeks. Alluvium along the Bitterroot River and its major tributaries is generally about 50 ft thick.

Ninemile Valley

Significant unconsolidated deposits in the Ninemile Valley are restricted to the lower portions of the alluvial valley along the creek. Thicknesses reach 150 ft in the valley near the confluence with the Clark Fork River, but decrease to less than 50 ft about 4 miles upstream. Alluvial fan and stream sediment along tributaries to Ninemile Creek are generally 20 ft thick, but may be as much as 50 ft thick as exposed at the surface. Placer gold deposits have been mined from unconsolidated deposits in several northeastern tributary valleys (Lange and Gignoux, 1999).

Potomac Area

In the Camas Prairie Creek valley near Potomac, Montana, and in Ninemile Prairie, only a few water wells penetrate broad areas of unconsolidated deposits. Near Potomac the Quaternary unconsolidated deposits are generally about 20 ft thick over weakly consolidated Tertiary sedimentary rocks. Few wells are completed in the thin Quaternary deposits. Of the 30 wells that penetrate Quaternary deposits in Ninemile Prairie, the unconsolidated deposits are about 50 ft thick. In both of the valleys the Quaternary unconsolidated deposits overlie sandy, silty, and locally gravelly Tertiary sedimentary rocks; the contact between the two units is not distinct everywhere.

Seeley Lake Area

Near the town of Seeley Lake the thickness of unconsolidated deposits was determined from many well logs. East of the town, in the southwest-directed valley along Seeley, Morrell, and Trail creeks, thicknesses range to greater than 200 ft in the valley center, and thin toward the edges of a partially filled paleovalley. The base of the unconsolidated deposits is an irregular surface. Glacial and alluvial erosion and re-deposition along the Clearwater River valley and its major tributaries are likely responsible for the distribution of sediments.

Clark Fork River Canyon

The thickness of unconsolidated deposits is as much as 500 ft in the narrow Clark Fork River valley downstream of Missoula in the Tarkio area (beyond the northwest end of the map). Along most of the canyon downstream of Huson, Quaternary unconsolidated deposits are commonly greater than 150 ft thick. However, near Alberton and the confluence of Ninemile Creek, and in the East Missoula area, as much as 200–250 ft of gravelly and silty alluvium is present. Because these areas are small and because of great local topographic relief, the thicknesses are difficult to show in detail at the map scale. In the canyon reaches upstream of Missoula, the alluvial deposits are more typically 50–100 ft thick.

MAP USE

These maps can be used to evaluate locations where shallow aquifers may exist and to help determine the location of sand and gravel resources near the land surface. These shallow aquifers could be susceptible to contamination from surface activities. Productive water wells occur mostly along stream valleys or downgradient of irrigation canals where the deposits are either continually or seasonally saturated with water. Most water wells completed in the unconsolidated deposits are in the Missoula Valley and along the Bitterroot and Clark Fork rivers. Many wells were also completed in the Seeley Lake area along Trail Creek, in the Potomac Valley, and in smaller tributary valleys throughout the region.

ACKNOWLEDGMENTS

This work was supported by the Ground-Water Characterization Program at the Montana Bureau of Mines and Geology. The map and text were improved due to reviews by Gary Icopini, Tom Patton, John Metesh, and Ed Deal.

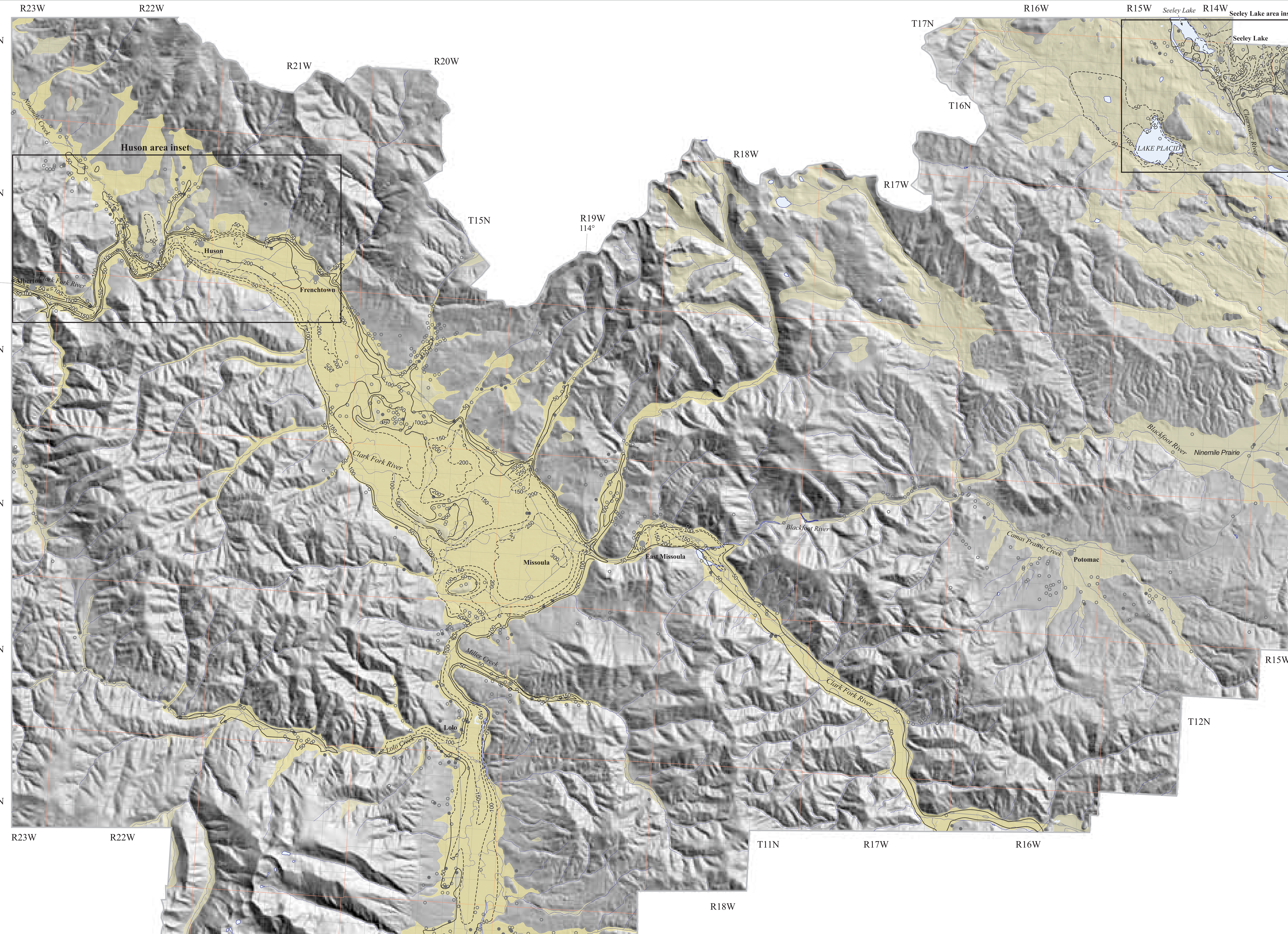
REFERENCES

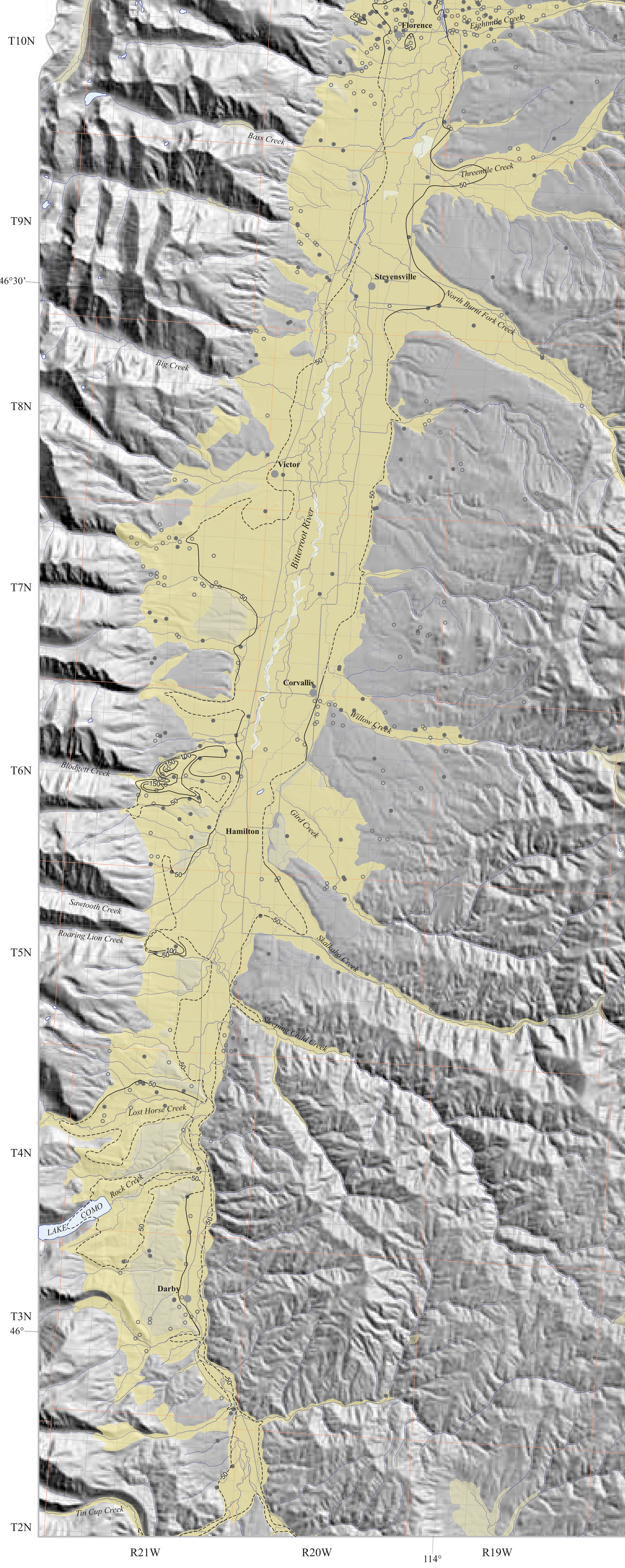
Lange, I.M., and Gignoux, T., 1999, Distribution, characteristics, and genesis of high fineness gold placers, Ninemile Valley, central-western Montana: Economic Geology and the Bulletin of the Society of Economic Geologists, v. 94, no. 3, p. 375–386.

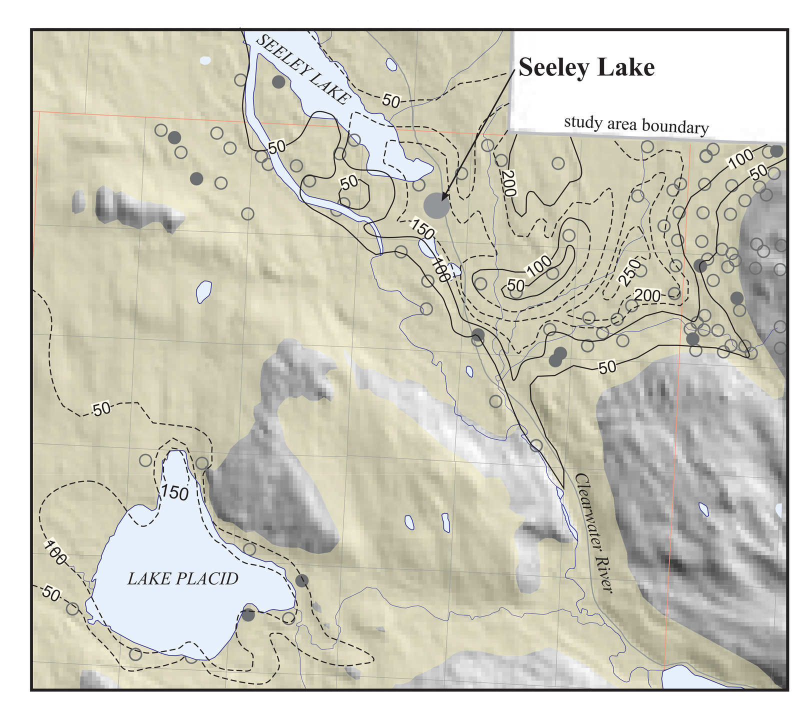
Smith, L.N., 2006a, Altitude of the Bedrock Surface, Mineral and Missoula counties, Montana (open file version): Montana Bureau of Mines and Geology Ground-Water Assessment Atlas 4B, Map 4, 1:150,000.

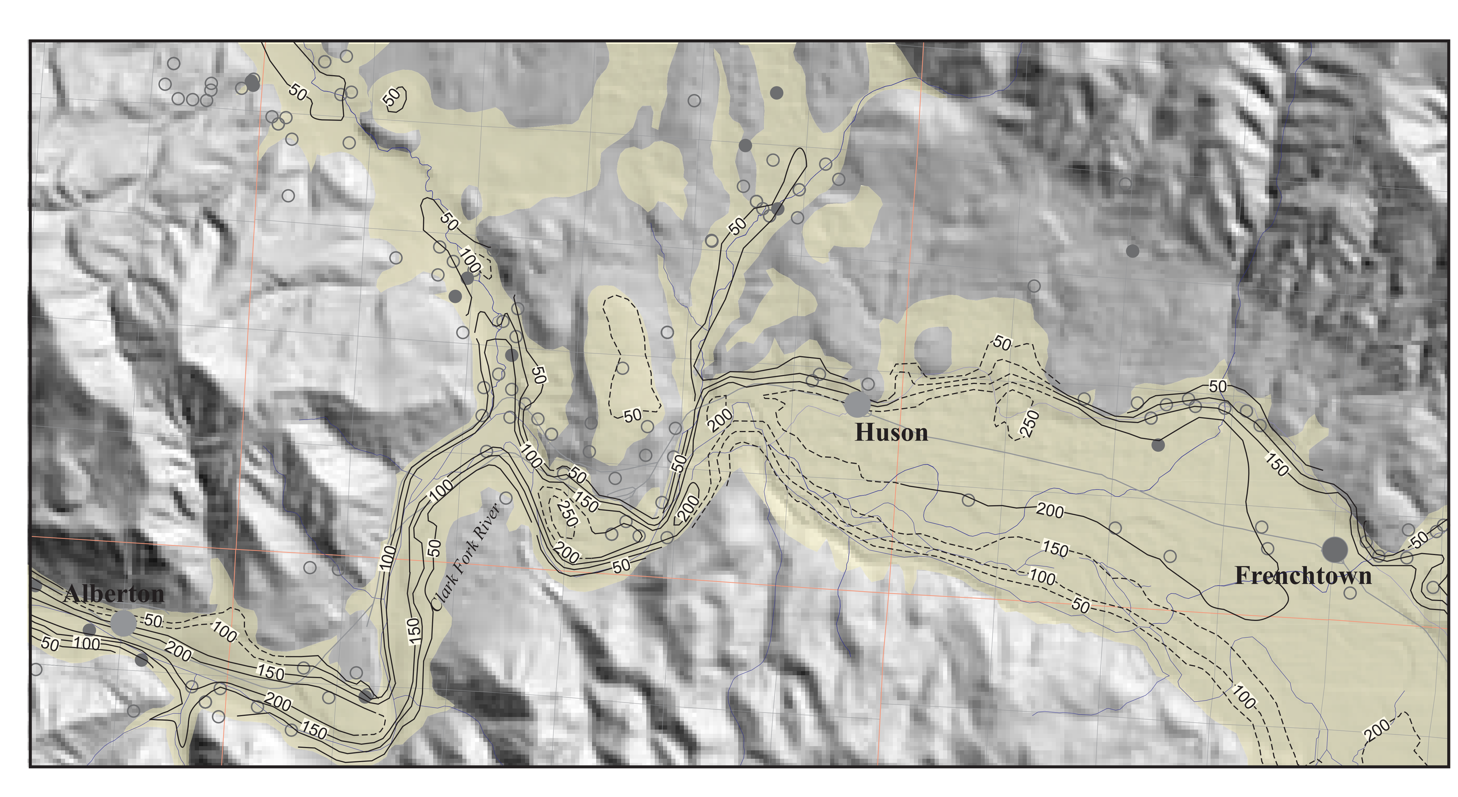
Smith, L.N., 2006b, Hydrogeologic framework of the Lolo-Bitterroot Area, Mineral, Missoula, and Ravalli counties, Montana (open file version): Montana Bureau of Mines and Geology Ground-Water Assessment Atlas 4B, Map 2, 1:250,000.

Smith, L.N., in press, Stratigraphic evidence for multiple drainings of Glacial Lake Missoula along the Clark Fork River, Montana, USA: Quaternary Research.









Explanation:

- Well that penetrates Quaternary unconsolidated deposits
- Well that penetrates Quaternary unconsolidated deposits (location verified in field)
- Quaternary unconsolidated deposits
- Contoured thickness of unconsolidated deposits, dashed where approximate
- City or town
- Study area boundary
- Section boundary
- Township boundary
- Principal road
- River or stream, canal
- Lake or reservoir
- Wetland

N

Scale 1:125,000

0 10 20 30 miles

Projection Montana State Plane
Datum NAD83